

CLAIMS

What is claimed is:

1. A fiducial calibration method for precisely and accurately manufacturing a part from a workpiece, the method comprising:
 - 5 providing a workpiece;
 - disposing a plurality of datums relative to the workpiece;
 - calibrating the separation distance between each of the plurality of datums to workpiece distance units;
 - disposing the workpiece in a machine;
 - 10 calibrating the machine to the workpiece distance units; and
 - manufacturing the part from the workpiece utilizing the calibrated machine.
2. The method of claim 1, further comprising periodically recalibrating the machine to the workpiece distance units.
3. The method of claim 1, wherein the workpiece and the machine are subject to
 - 15 environmental and structural variations.
4. The method of claim 3, wherein the workpiece and the machine are subject to thermal variations.
5. The method of claim 1, wherein disposing the plurality of datums relative to the workpiece comprises selecting a plurality of datums associated with the workpiece,
 - 20 wherein each of the plurality of datums is inherent in or intrinsic to the workpiece.
6. The method of claim 1, wherein the plurality of datums comprise fabricated datums.
7. The method of claim 1, wherein the plurality of datums comprise removable datums.
8. The method of claim 1, wherein the plurality of datums comprise virtual datums.
9. The method of claim 1, wherein the plurality of datums comprise a plurality of datums selected from the group consisting of tooling balls, sockets, marks, geometric stock material features, geometric workpiece features, implanted atoms, deposited atoms, and tagged atoms.
10. The method of claim 1, wherein the part to be manufactured from the workpiece
 - 30 comprises a micro-scale part.

11. The method of claim 1, wherein the part to be manufactured from the workpiece comprises a macro-scale part.

12. The method of claim 1, wherein the part to be manufactured from the workpiece comprises a nano-scale part.

5 13. ✓ A fiducial calibration method for precisely and accurately manufacturing a part from a workpiece, the method comprising:

providing a workpiece, wherein the workpiece is subject to environmental and structural variations;

disposing a plurality of datums on a surface of or within the workpiece;

10 calibrating the separation distance between each of the plurality of datums to workpiece distance units;

disposing the workpiece in a machine, wherein the machine is subject to environmental and structural variations;

calibrating a coordinate system of the machine to the workpiece distance units;

15 manufacturing the part from the workpiece utilizing the calibrated machine; and periodically recalibrating the machine to the workpiece distance units.

14. The method of claim 13, wherein the workpiece and the machine are subject to thermal variations.

20 15. The method of claim 13, wherein disposing the plurality of datums on the surface of or within the workpiece comprises selecting a plurality of datums associated with the workpiece, wherein each of the plurality of datums is inherent in or intrinsic to the workpiece.

16. The method of claim 13, wherein the plurality of datums comprise fabricated datums.

25 17. The method of claim 13, wherein the plurality of datums comprise removable datums.

18. The method of claim 13, wherein the plurality of datums comprise virtual datums.

30 19. The method of claim 13, wherein the plurality of datums comprise a plurality of datums selected from the group consisting of tooling balls, sockets, marks, geometric stock material features, geometric workpiece features, implanted atoms, deposited atoms, and tagged atoms.

20. ✓ A fiducial calibration method for precisely and accurately assembling a plurality of manufactured parts, the method comprising:

providing a plurality of parts, the plurality of parts having a plurality of datums relative to each of the plurality of parts;

5 positioning and aligning the plurality of parts utilizing the plurality of datums; and assembling the plurality of parts.

21. The method of claim 20, wherein each of the plurality of parts is subject to environmental and structural variations.

22. The method of claim 21, wherein each of the plurality of parts is subject to
10 thermal variations.

23. The method of claim 20, wherein the plurality of datums comprise inherent or intrinsic datums.

24. The method of claim 20, wherein the plurality of datums comprise fabricated datums.

15 25. The method of claim 20, wherein the plurality of datums comprise removable datums.

26. The method of claim 20, wherein the plurality of datums comprise virtual datums.

27. The method of claim 20, wherein the plurality of datums comprise a plurality of datums selected from the group consisting of tooling balls, sockets, marks, geometric
20 stock material features, geometric workpiece features, implanted atoms, deposited atoms, and tagged atoms.

28. The method of claim 20, wherein the plurality of parts to be assembled comprise micro-scale parts.

29. The method of claim 20, wherein the plurality of parts to be assembled comprise
25 macro-scale parts.

30. The method of claim 20, wherein the plurality of parts to be assembled comprise nano-scale parts.

31. ✓ A fiducial calibration method for precisely and accurately assembling a plurality of manufactured parts, the method comprising:

providing a plurality of parts, the plurality of parts having a plurality of datums on a surface of or within each of the plurality of parts, wherein each of the plurality of parts is subject to environmental and structural variations;

5 calibrating the separation distance between each of the plurality of datums to workpiece distance units;

disposing the plurality of parts in a machine operable for assembling the plurality of parts, wherein the machine is subject to environmental and structural variations;

calibrating a coordinate system of the machine to the workpiece distance units;

assembling the plurality of parts utilizing the calibrated machine; and

10 periodically recalibrating the machine to the workpiece distance units.

32. The method of claim 31, wherein the plurality of parts and the machine are subject to thermal variations.

33. The method of claim 31, wherein the plurality of datums comprise inherent or intrinsic datums.

15 34. The method of claim 31, wherein the plurality of datums comprise fabricated datums.

35. The method of claim 31, wherein the plurality of datums comprise removable datums.

36. The method of claim 31, wherein the plurality of datums comprise virtual datums.

20 37. The method of claim 31, wherein the plurality of datums comprise a plurality of datums selected from the group consisting of tooling balls, sockets, marks, geometric stock material features, geometric workpiece features, implanted atoms, deposited atoms, and tagged atoms.

25 38. A fiducial calibration system for precisely and accurately manufacturing a part from a workpiece, the system comprising:

a workpiece having a surface, wherein the workpiece is subject to environmental and structural variations;

a plurality of datums disposed relative to the workpiece;

30 a machine operable for holding the workpiece and manufacturing a part from the workpiece, wherein the machine is subject to environmental and structural variations;

means for calibrating the separation distance between each of the plurality of datums to workpiece distance units;

means for calibrating a coordinate system of the machine to the workpiece distance units; and

5 means for periodically recalibrating the machine to the workpiece distance units.

39. The system of claim 38, wherein the workpiece and the machine are subject to thermal variations.

40. The system of claim 38, wherein each of the plurality of datums disposed relative to the workpiece comprises a datum that is inherent in or intrinsic to the workpiece.

10 41. The system of claim 38, wherein the plurality of datums comprise fabricated datums.

42. The system of claim 38, wherein the plurality of datums comprise removable datums.

43. The system of claim 38, wherein the plurality of datums comprise virtual datums.

15 44. The system of claim 38, wherein the plurality of datums comprise a plurality of datums selected from the group consisting of tooling balls, sockets, marks, geometric stock material features, geometric workpiece features, implanted atoms, deposited atoms, and tagged atoms.

45. ✓ A fiducial calibration system for precisely and accurately assembling a plurality
20 of manufactured parts, the system comprising:

a plurality of parts, the plurality of parts having a plurality of datums disposed on a surface of or within each of the plurality of parts, wherein each of the plurality of parts is subject to environmental and structural variations;

25 a machine operable for holding and assembling the plurality of parts, wherein the machine is subject to environmental and structural variations;

means for registering the separation distance between each of the plurality of datums into workpiece distance units;

means for calibrating a coordinate system of the machine to the workpiece distance units; and

30 means for periodically recalibrating the machine to the workpiece distance units.

46. ✓ A fiducial calibration method for precisely and accurately measuring a workpiece, the method comprising:

providing the workpiece, wherein the workpiece is subject to environmental and structural variations;

5 disposing a plurality of datums relative to the workpiece;

calibrating the separation distance between each of the plurality of datums to workpiece distance units;

disposing the workpiece in a measuring machine, wherein the measuring machine is subject to environmental and structural variations;

10 calibrating a coordinate system of the measuring machine to the workpiece distance units;

measuring the workpiece utilizing the calibrated measuring machine; and

periodically recalibrating the measuring machine to the workpiece distance units.

47. The method of claim 46, wherein each of the plurality of datums comprises a datum selected from the group consisting of a inherent datum, an intrinsic datum, a fabricated datum, a removable datum, and a virtual datum.

48. The method of claim 46, wherein each of the plurality of datums comprises a datum selected from the group consisting of a tooling ball, a socket, a mark, a geometric stock material feature, a geometric workpiece feature, an implanted atom, a deposited atom, and a tagged atom.

49. The method of claim 46, wherein the workpiece is subject to a manufacturing process following the calibration of the datums.